Fisheries and Oceans Canada / Pêches et Océans Canada
Ecosystems and Oceans Science / Sciences des écosystèmes et des océans
Canadian Science Advisory Secretariat
Science Response 2016/035
Maritimes Region

REVIEW OF SCOTIAN SHELF SNOW CRAB ASSESSMENT RESULTS FOR 2015

Context

Advice on the status of the Scotian Shelf Snow Crab stock is requested annually by Fisheries and Oceans Canada (DFO) Fisheries and Aquaculture Management Branch, and Industry, to help determine a Total Allowable Catch (TAC) for 2016. Science advice for the management of the Snow Crab stock was last provided at a fully peer-reviewed stock assessment at an inclusive Regional Advisory Process (RAP) meeting in February 2015 (Cook et al. 2015). The current report provides information on the post fishery stock status for 2015, and advice for management of the 2016 fishery.

This Science Response Report results from the Science Response Process of March 3, 2016, on the Stock Status Update of Eastern Scotian Shelf and Northwest Atlantic Fisheries Organization (NAFO) Fishing Area 4X Snow Crab.

Background

Description of the Fishery

The Snow Crab fishery in eastern Canada began in 1960 with incidental by-catches by groundfish draggers near Gaspe, Quebec. Its development was slow until the 1980s, when it began expanding rapidly to become one of the largest fisheries in Canada in terms of landings and landed value. On the Scotian Shelf, the fishery has existed since the early 1970s. The fishery was initially based on effort controls (season, license, trap limits) from 1982 to 1993 with harvesting during June – November of hard-shelled males larger than 95 mm carapace width (CW). Additional management measures were introduced from 1994 to 1999: individual boat quotas (IBQs), TACs, 100% dockside monitoring, mandatory logbooks, and at-sea monitoring by certified observers. In 2005, many Crab Fishing Areas (CFAs) and subareas were merged with the resulting divisions being N-ENS (North-Eastern Nova Scotia, formerly CFAs 20-22), S-ENS (South-Eastern Nova Scotia, CFAs 23, 24), and 4X (Figure 1).

Figure 1. Map of the Scotian Shelf and Snow Crab Fishing Areas (CFAs).

Effort

In 2015, the fishing effort in S-ENS, was spatially distributed in a similar manner to 2014 (Figure 2), with a shift away from inshore fishing grounds in both CFAs 23 and 24. Much of the fishing effort continued to be focused on the holes found between Misaine and Banquereau Banks. There was a complete absence of effort in the western portion (along the "Eastern Shore") of CFA 24. Fishing patterns were affected by an overlap with spring fishing activities for shrimp, as the Snow Crab fleet has limited access to some of the most productive Snow Crab fishing zones throughout the spring months, due to area closures ("shrimp boxes"). Temporal trends in effort are presented in Figure 3.

In N-ENS, the fishing effort was focused on the trench of deep water located along the north-eastern coast of Cape Breton and in the Glace Bay Hole.

In 4X, the fishing effort was similar to the previous season. Fishing effort was concentrated around Sambro and Roseway Basin.

The spring season (2008 - present) was adopted to reduce fishing intensity in the summer season and to encourage fishing during the earlier period when newly molted crab are too weak and soft to easily enter into traps. Since 2010, the majority of landings (60%) from N- and S-ENS were caught during the spring season. Spring landings in 2015 decreased in both areas, particularly in N-ENS (21%), due to spring ice conditions. The capture of soft-shelled crab (<68 on durometer, a hardness gauge) represented less than 5% of catches in all commercial areas in 2015.

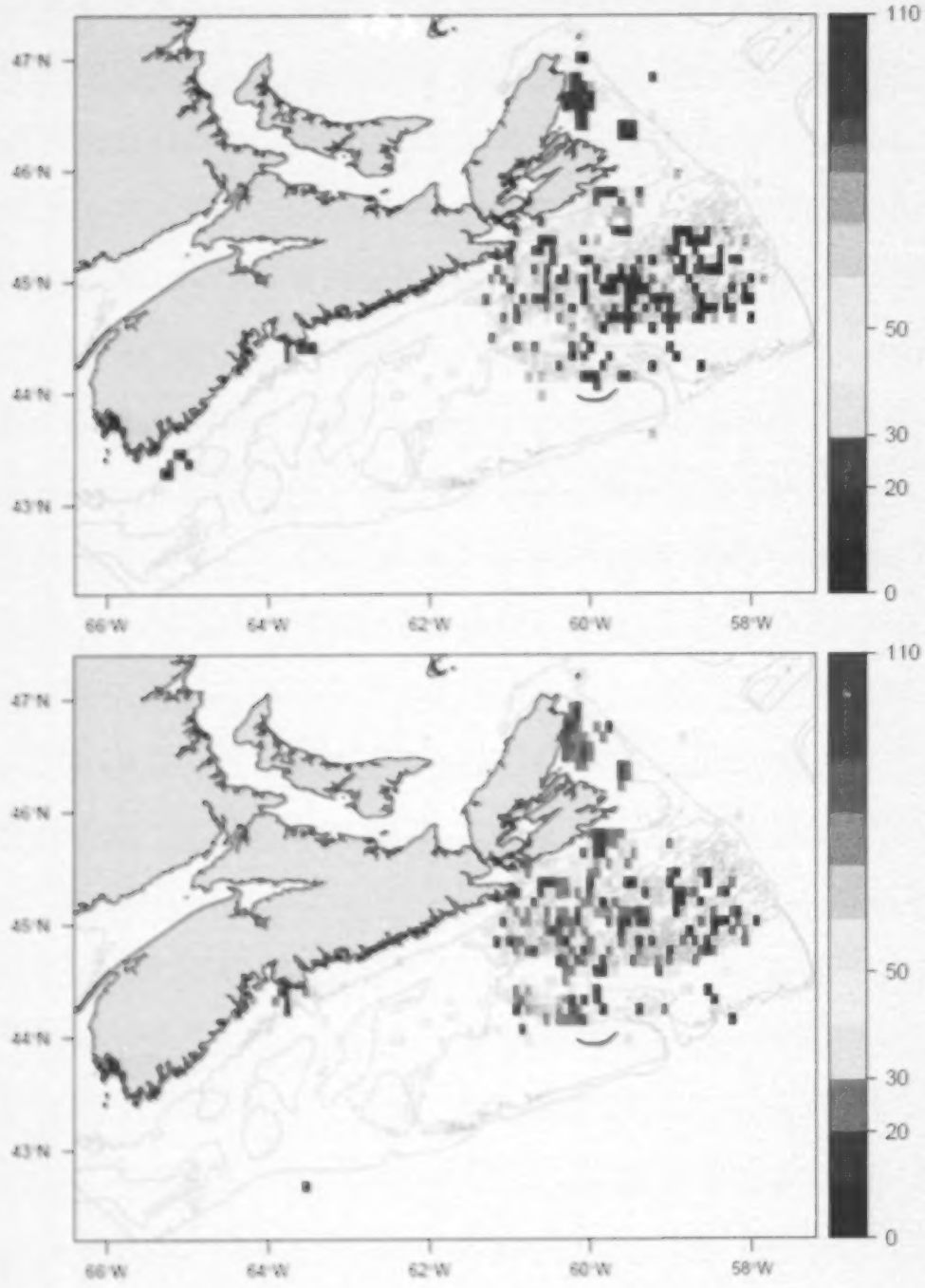


Figure 2. The spatial distribution of fishing effort (traps hauled) from fisheries logbook data for 2014 (top) and 2015 (bottom). For 4X, year refers to the starting year.

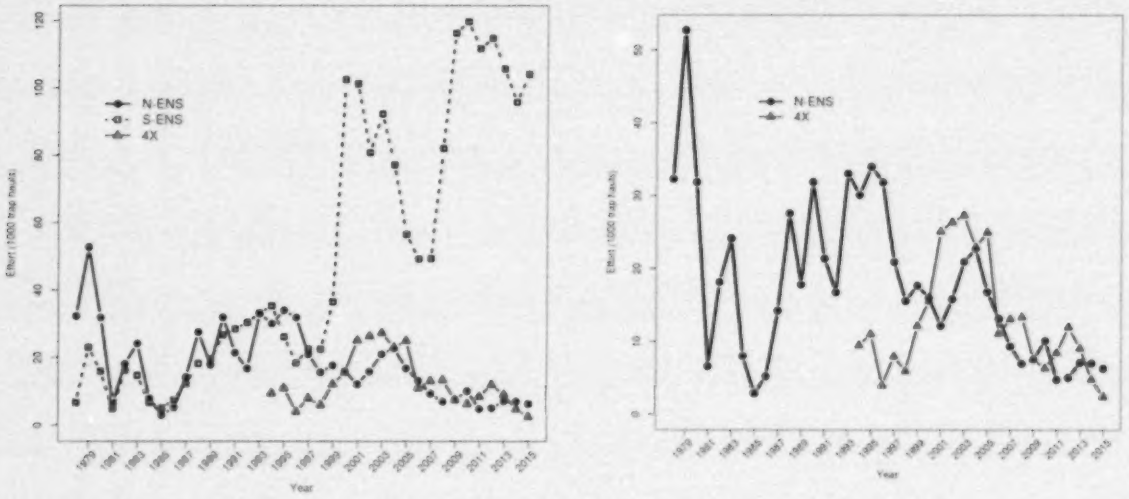


Figure 3. Temporal variations in fishing effort for Snow Crab on the Scotian Shelf, expressed as the number of trap hauls per 1 minute grid. Year in 4X refers to the year at the end of the fishing season

Landings

The Scotian Shelf Snow Crab fishery lands only males with CW greater than or equal to 95 mm. There is also a concerted effort to avoid areas of newly moulted (soft shelled) crab and to discard immature males. Total landings increased to record levels of approximately 10,000 t each year in the early 2000s and have surpassed these previous highs since 2009 (Figure 4). Landings in 2015 for N-ENS and S-ENS were 619 t and 11,292 t, respectively, which represent a 20% drop in landings for N-ENS; however, this closely follows the TACs for each region (Figure 4). As of February 25, 2016, landings in 4X for the 2014/2015 season were 120 t. This represents a 50% increase over the 2014/2015 season; however, the TAC in this area was increased by 85%. Total allowable catches in 2015 were 624 t, 11,311 t, and 150 t for N-ENS, S-ENS and 4X, respectively (Table 1).

In S-ENS, the spatial distribution of landings in 2015 (Figure 5) were similar to 2014 with a few exceptions; a reduction inshore, northeast of Sable Island (in CFA 24) and northwest of Banquereau Bank (CFA 23). In N-ENS in 2015, landings were focused on the trench of deep water located on the north-eastern coast of Cape Brenton and the Glace Bay Hole (Figure 5). There was little change in the spatial distribution of landings in 4X, with the majority of landings occurring proximal to the CFA 24 line.

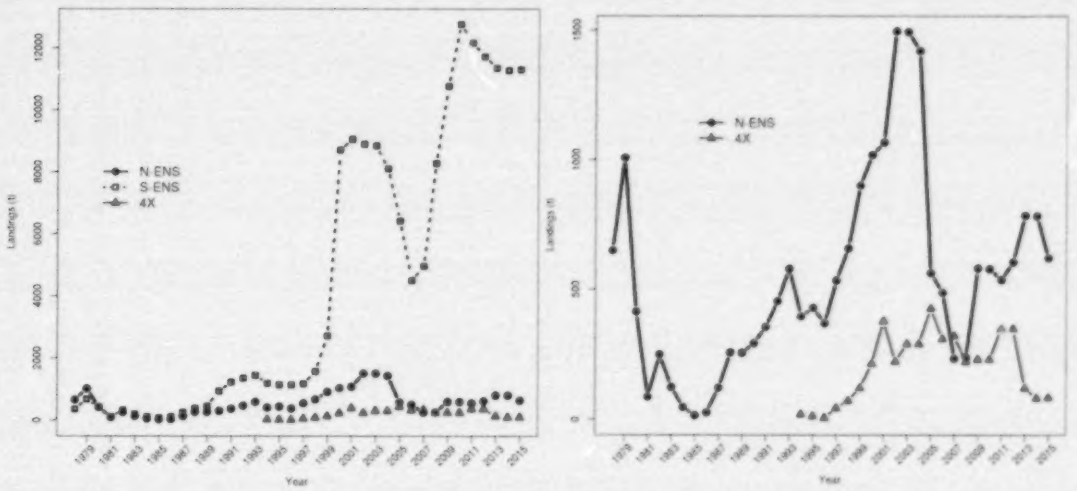


Figure 4. Temporal variations in the landings of Snow Crab on the Scotian Shelf (t). Note the sharp increase in landings associated with dramatic increases to total allowable catches (TACs) and a doubling of fishing effort in the year 2001. The landings follow the TACs with little deviation (Table 1). Year in 4X refers to the year at the start of the fishing season.

Table 1. Summary of Snow Crab fisheries activity of N-ENS (top), S-ENS (middle), and 4X (bottom). Landings are measured in tonnes, Catch per Unit Effort (CPUE) is measured as kg/trap hauled, while effort is measured per 1000 trap hauls. Note that 2015/2016 4X season data is current to February 25, 2016, as season is still ongoing. (-- = effort not available until close of fishing season.)

N-ENS					
Year	**Licenses**	**TAC**	**Landings**	**CPUE**	**Effort**
2010	78	576	576	55	10.50
2011	78	534	536	110	4.80
2012	78	603	603	117	5.10
2013	78	783	783	106	7.40
2014	78	783	778	104	7.40
2015	78	623	619	103	6.00
S-ENS					
Year	**Licenses**	**TAC**	**Landings**	**CPUE**	**Effort**
2010	116	13,200	13,150	103	128.30
2011	116	12,120	12,135	106	118.80
2012	116	11,707	11,733	98	120.00
2013	116	11,311	11,309	104	108.70
2014	116	11,311	11,300	112	100.20
2015	116	11,311	11,292	106	106.23
4X					
Year	**Licenses**	**TAC**	**Landings**	**CPUE**	**Effort**
2009/10	9	230	229	36	6.4
2010/11	9	346	345	38	9.0
2011/12	9	346	344	29	11.0
2012/13	9	263	118	13	9.6
2013/14	9	80	79	15	5.1
2014/15	9	80	82	36	2.4
2015/16*	9	150	120	34	--

*current to February 25, 2016

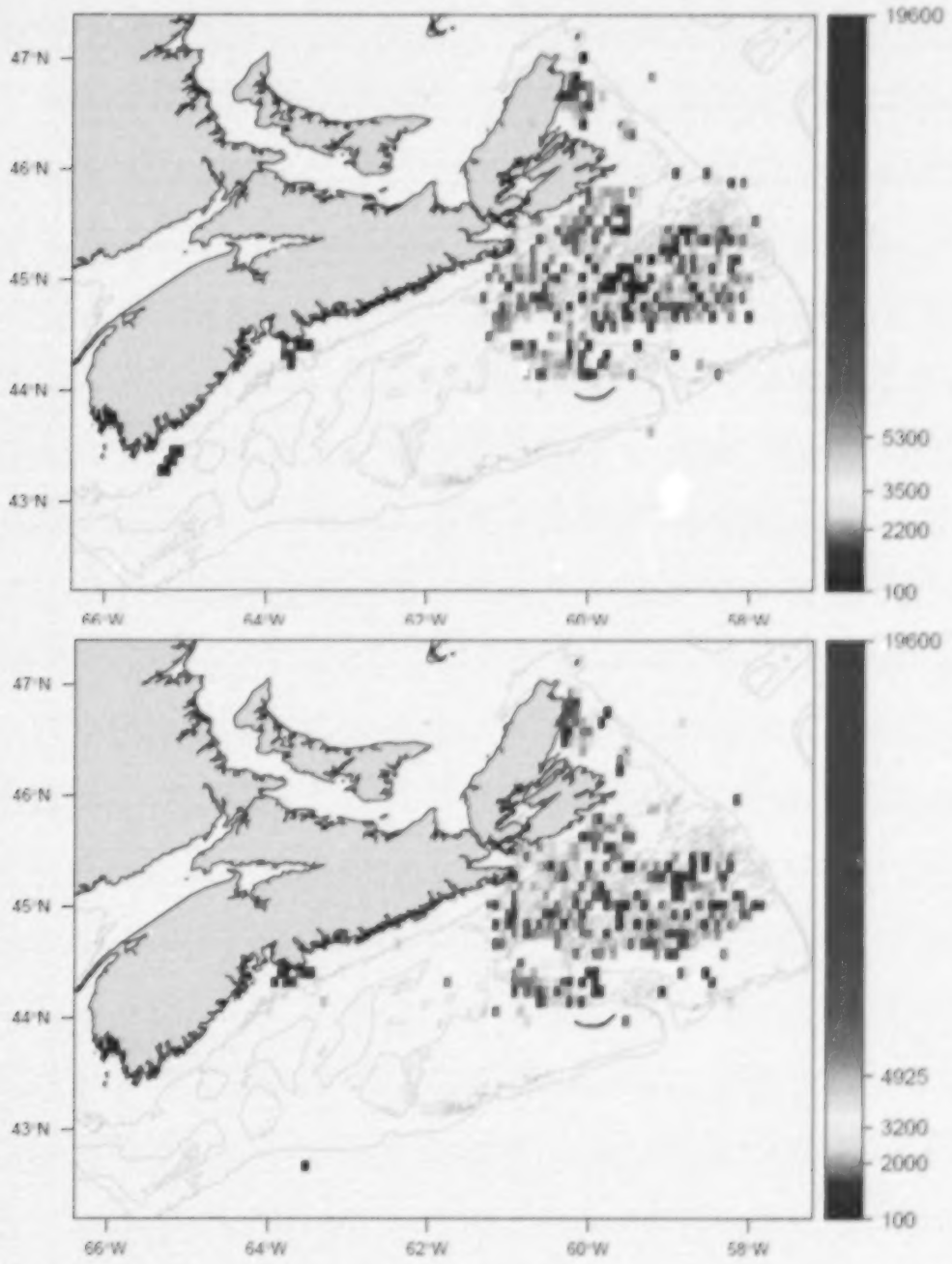


Figure 5. The spatial distribution of Snow Crab landings (kg/5 minute grid) from fisheries logbook data for 2014 (top) and 2015 (bottom). Note the decrease in landings inshore in S-ENS compared to 2014. For 4X, year refers to the starting year.

Catch Rates

Non-standardized catch rates in 2015 (Figure 6) were 103 kg/trap haul in N-ENS, 106 kg/trap haul in S-ENS, and 34 kg/trap haul in 4X in 2015/2016, which compared to the previous year represents decreases of 4%, 6%, and 5% in N-ENS, S-ENS, and 4X, respectively (Table 1, Figures 6-7). The spatial distribution of catch rates was similar to 2014, with the exception of decreases inshore, northeast of Sable Island, and northwest of Banquereau Bank in S-ENS (Figure 7).

All results for 2015 for 4X are preliminary as the season is ongoing until the end of March.

Figure 6. Temporal variations in catch rates of Snow Crab on the Scotian Shelf, expressed as kg per trap haul. These catch rates are not corrected for various factors such as trap design and size, soak time, bait, etc. For 4X, year refers to the starting year.

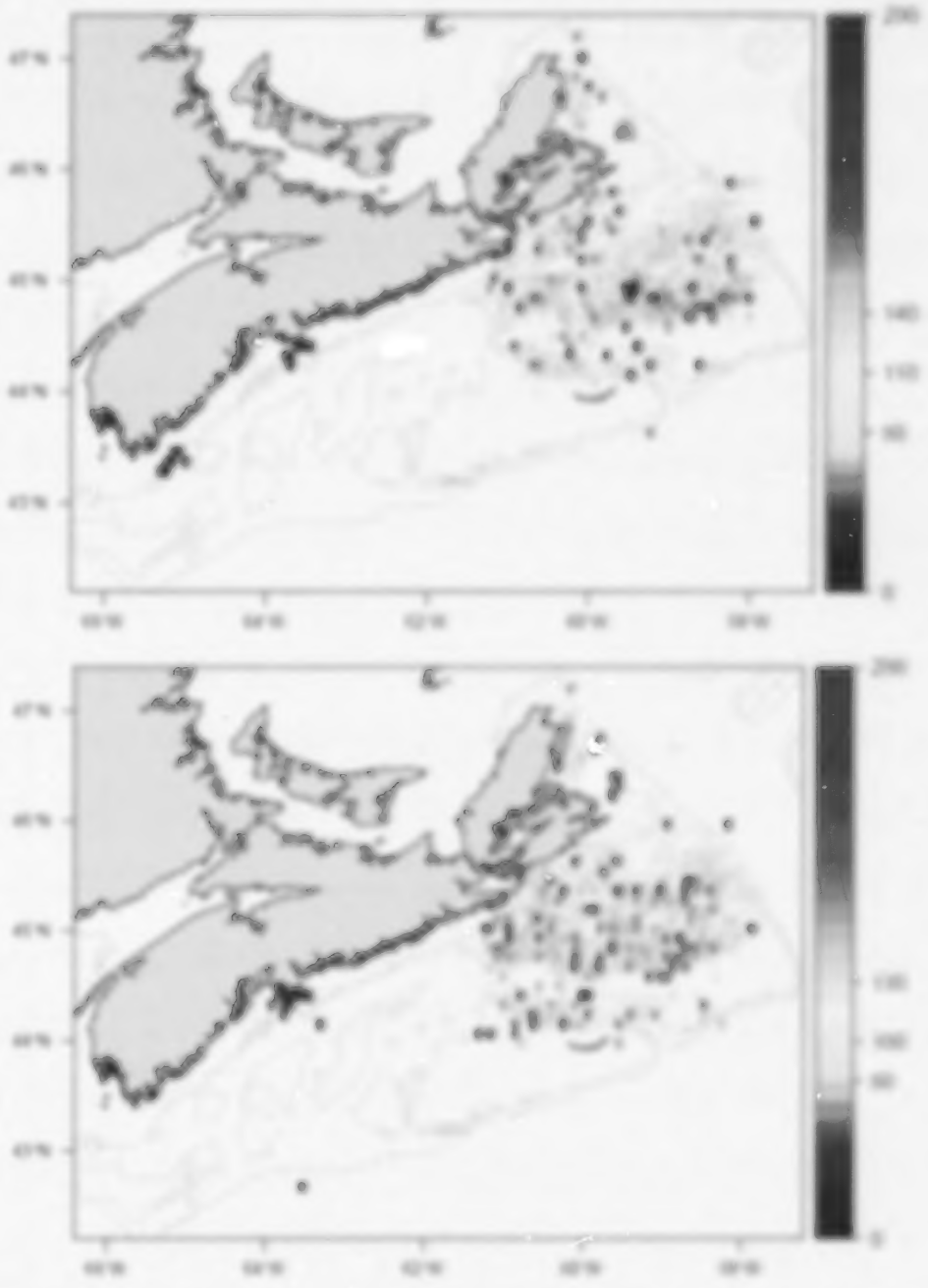


Figure 7. The spatial distribution of Snow Crab catch rates (kg/trap haul) from fisheries logbook data for 2014 (top) and 2015 (bottom). Note the decrease in catch rates inshore in 3-ENS and in the eastern portion of the Eastern Holes. For 4X, year refers to the starting year.

Analysis and Response

A reference points-based Precautionary Approach (PA) has been implemented in this fishery. The Limit Reference Point (LRP) is 25% of carrying capacity and the Upper Stock Reference (USR) is 50% of carrying capacity. The target removal reference is 20% of the fishable biomass[1] in each area and the Removal Reference is not to exceed F_{MSY}[2]. Various secondary population and ecosystem indicators are taken into consideration for management decisions.

Harvest Control Rules (HCR) have been developed that link the biomass reference points to the exploitation reference points. In the Cautious and Healthy zones, actual target harvest rates are shaped by a suite of secondary indicators that provide more complete information on the entire stock's health. The secondary indicators are used to inform management decision under the HCR linking the stock references to harvest strategies. Secondary indicators include expected recruitment, spawning stock biomass, size and age structure of various stock components, sex ratios, environmental variables, fishery performance, and others. If a stock is determined to be in the Critical Zone, all fishing activities cease, in an effort to allow the stock to rebuild.

The operational reference points associated with the 4VWX Snow Crab fishery are as follows:

- **Lower Stock Reference (LSR):** 25% of carrying capacity
- **Upper Stock Reference (USR):** 50% of carrying capacity
- **Removal Reference (RR):** not to exceed F_{MSY}
- **Target Removal Reference (TRR):** 20% of the fishable biomass (F=0.22). Secondary contextual indicators are used to alter harvest rates between 10 and 30% of fishable biomass (F=0.11 to F=0.36)

The Harvest Control Rules are, therefore, as follows:

- FB > USR: target exploitation rate of 10% - 30% be utilized, based upon contextual information provided by secondary indicators
- LSR < FB < USR: target exploitation rate of 0% - 20%, based upon contextual information provided by secondary indicators
- FB < LSR: fishery closure until recovery (at a minimum, until FB > LSR)

Ecosystem Considerations

Temperature

Average bottom temperatures recorded during the Snow Crab survey in 2015 were lower in all areas in comparison to 2014 (Figure 8). The Snow Crab survey more heavily surveys "core areas" of Snow Crab habitat, and does not represent the patterns on the Eastern Scotian Shelf in general. Scotian Shelf temperatures outside the "core areas" of Snow Crab habitat were warmer in 2015, potentially limiting the geographic extent of Snow Crab populations (Figure 8). It is anticipated that warmer temperatures outside primary Snow Crab habitat may affect future fishable biomass. Warmer temperatures would limit the available habitat for female and immature male crab more than the current fishable biomass. Following the extreme warm water

[1] The weighted of the Snow Crab biomass that is male, mature, larger than 95 mm CW and hard-shelled (with a durometer measure of 68 or greater).
[2] F is the fishing mortality of the legal sized mature male population and MSY is the theoretical Maximum Sustainable Yield.

event in 2012. bottom temperatures have decreased in 4X during the past three years, however they still remain at the long-term mean for the area. In 3-Cntl, and 4-Cntl temperatures decreased close to the long-term mean for the areas.

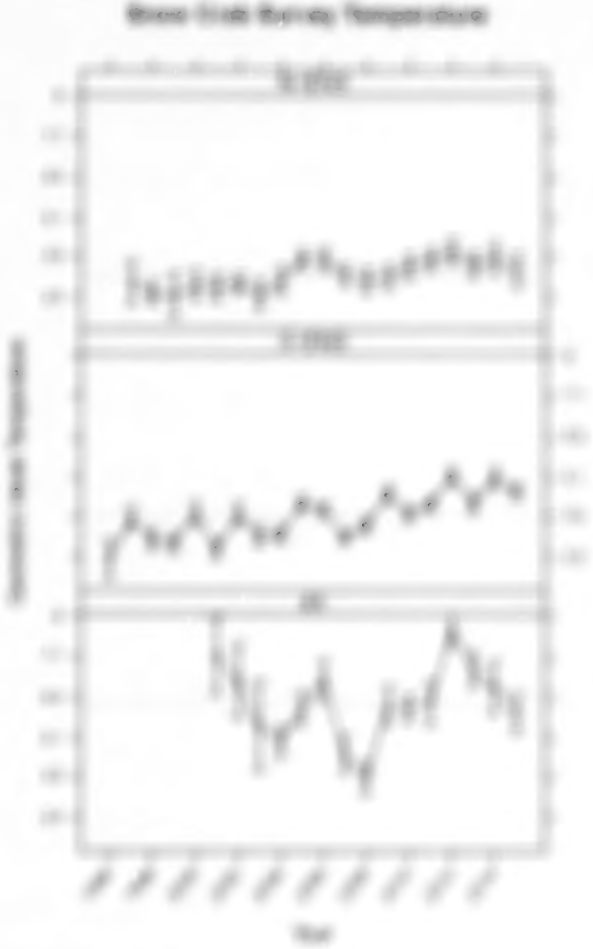


Figure 6. Annual variations in bottom temperature observed during the Snow Crab Survey. The horizontal line indicates the long-term median temperature within each sub-area. Error bars are 1 standard deviation from the mean.

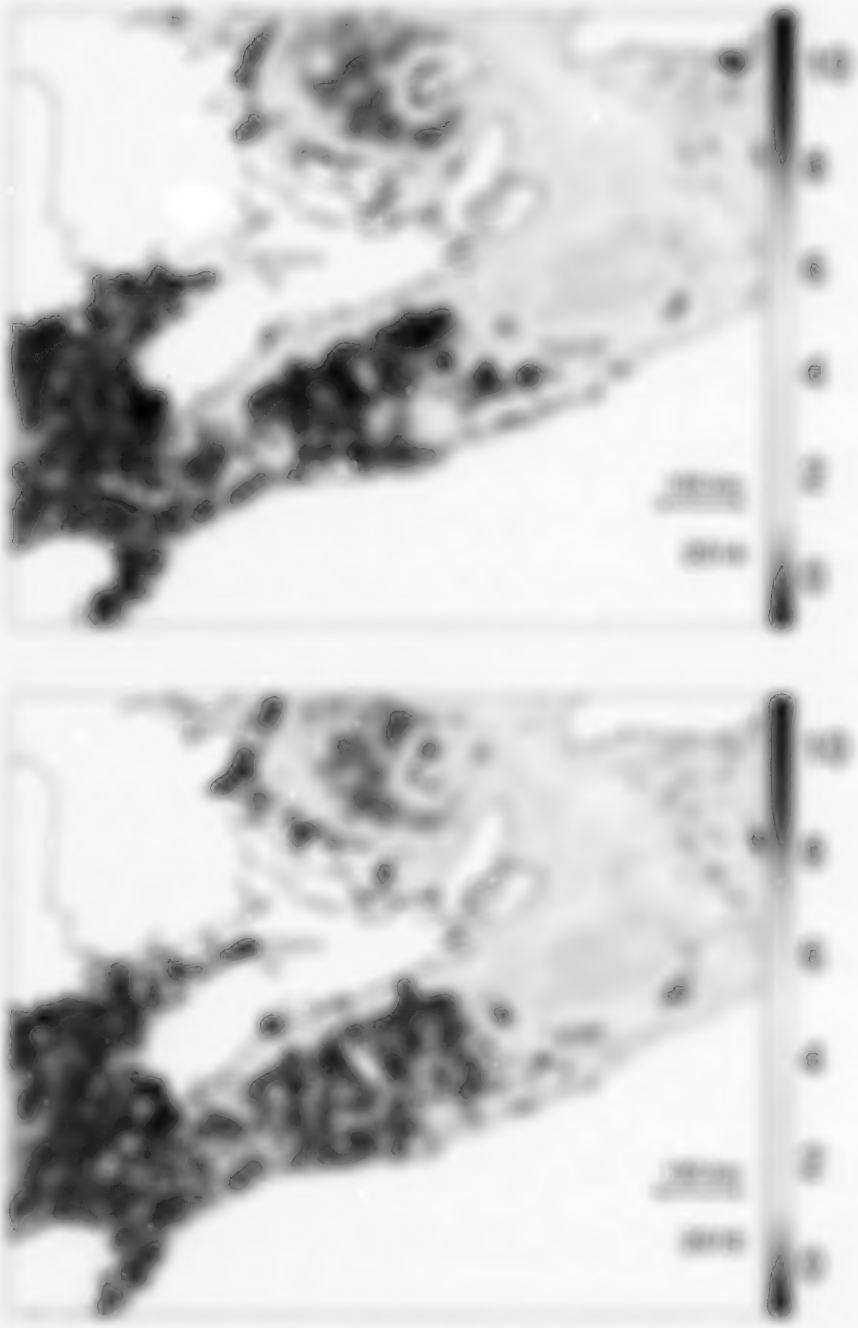
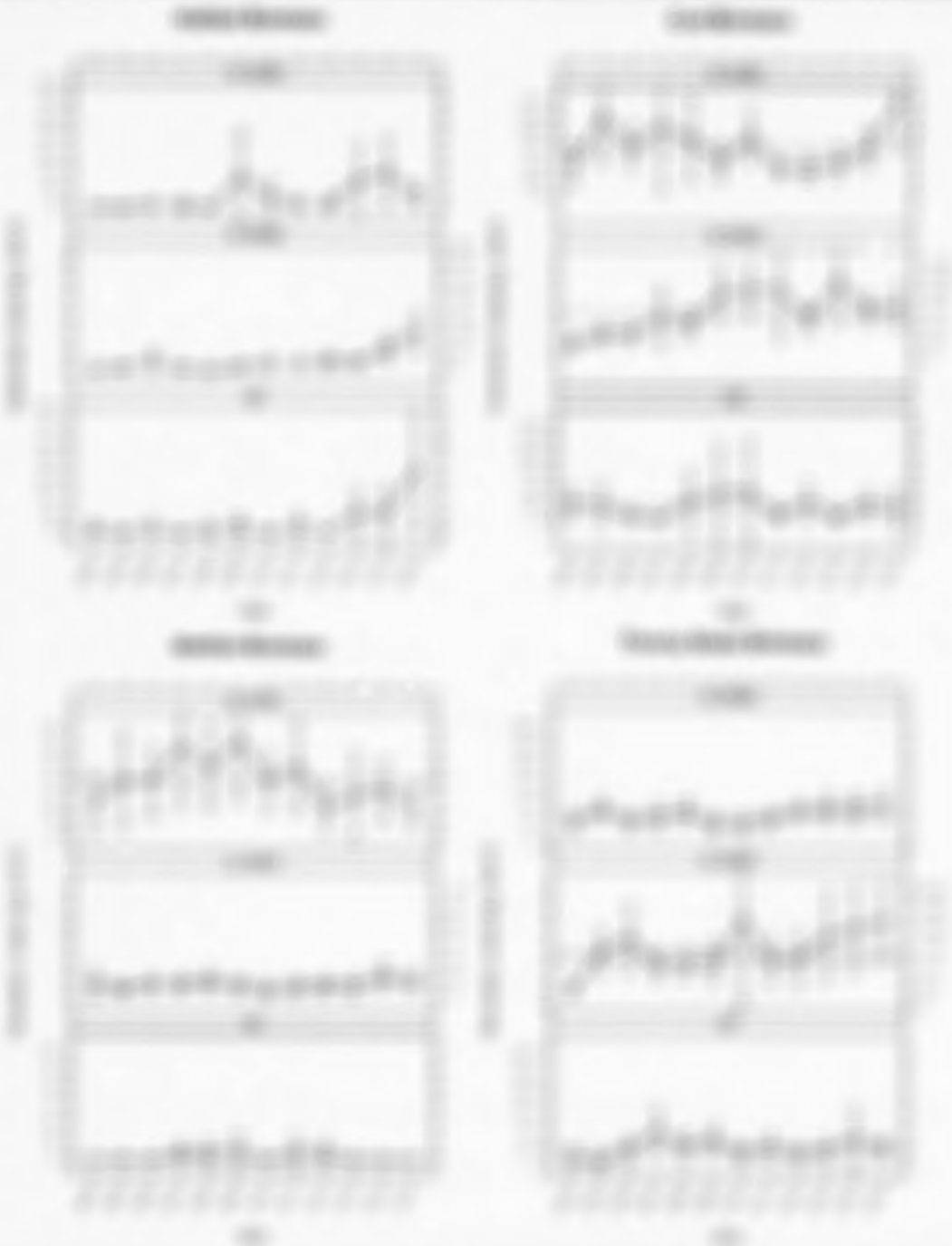


Figure 9. Interpolated mean annual bottom temperature in the Scotian Shelf for selected year. These interpolations are of available water temperature data collected in the area including Groundfish Surveys, Snow Crab surveys, and SCMP monitoring stations.



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Fishery Status

Commercial Catch Composition

There has been a shift towards larger animals in N-ENS catches in the past four years, suggesting higher survival of immature crab (lack of handling mortality of soft-shelled crab), while catches in S-ENS have shown a more stable mean crab size (Figure 11). Crab caught in 4X showed an increase in mean size after two consecutive years of decreases.

Carapace condition (CC; Table 2) defines the approximate age (since terminal moult) of the crab based on the relative development and subsequent decay of the carapace. Carapace conditions of commercial catches are subjectively determined by at-sea fisheries observers and can be affected by individual assessment of CC, time of year, etc. Fewer CC2 and more CC3 crab were observed in the catch in 2015, as compared to 2014, in both N-ENS and S-ENS (Figures 12 and 13). 4X catches showed a reduction in CC2 and CC3 with an associated increase in CC4 (Figure 14). No appreciable amount of CC5 crab are observed in any area.

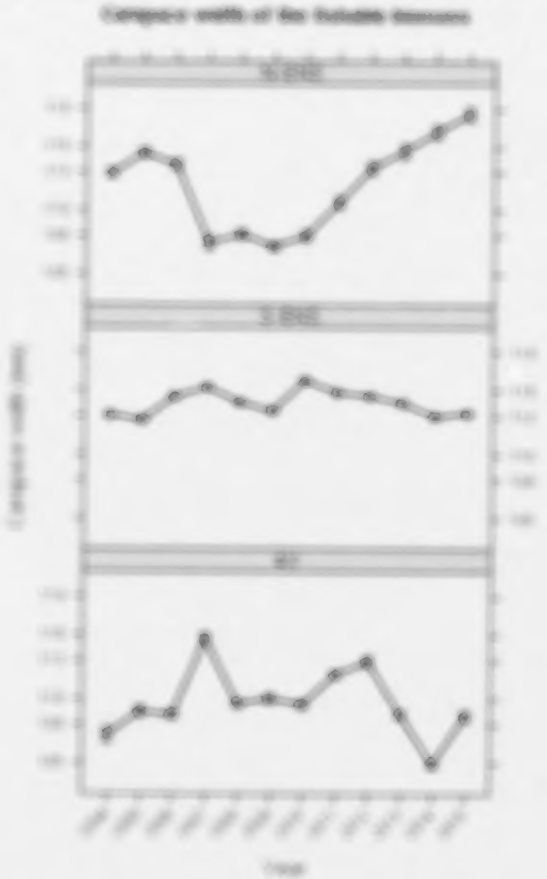


Figure 11. Time series of geometric mean carapace width of commercial crab measured by at-sea-observers. Vertical lines represent 95% confidence intervals. For 4X, the year refers to the end year of the season.

Table 2. Snow Crab carapace conditions (CC) and their description. Hardness is measured by a durometer.

Carapace Condition (CC)	Category	Hardness	Age after Terminal Molt (approx.)
1	New soft	< 68	0 - 5 months
2	Clean	variable	5 months – 1 year
3	Intermediate	> 68	8 month – 3 years
4	Old	> 68	2 - 5 years
5	Very old	variable	4 - 6 years

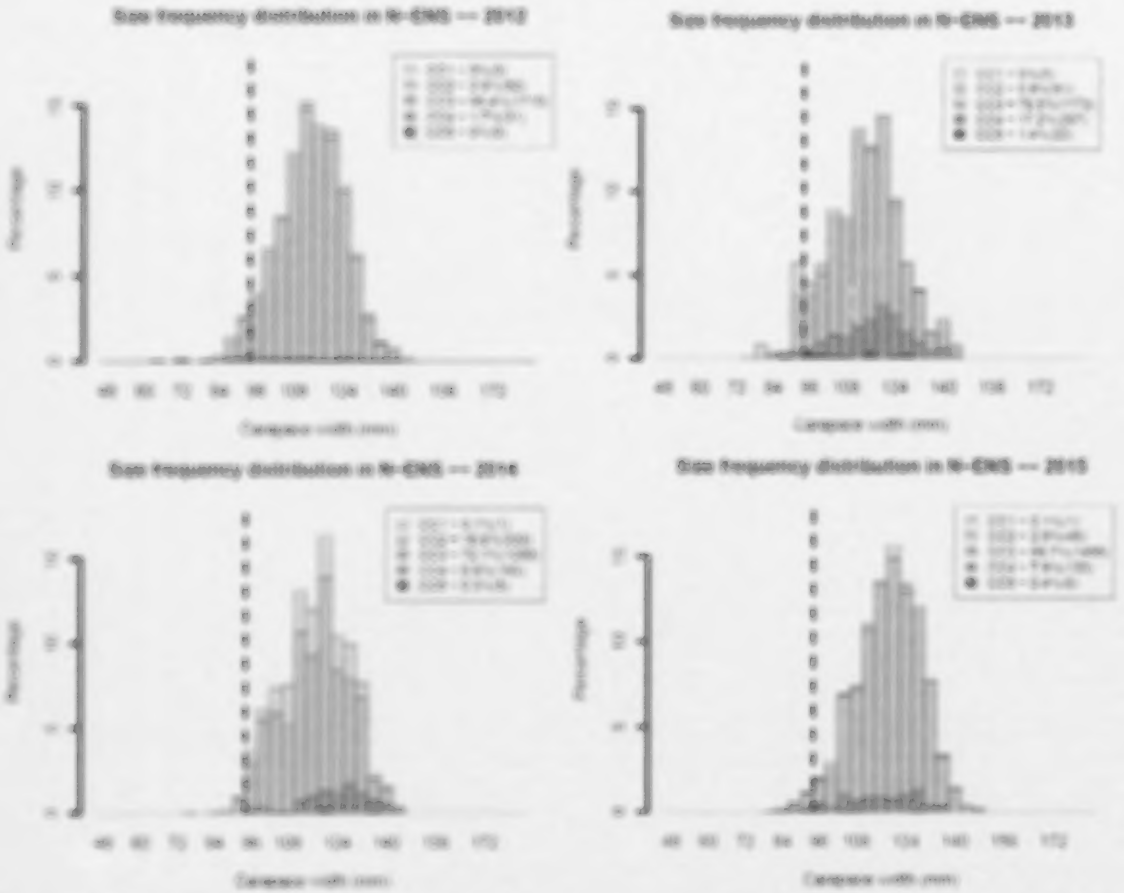

Size frequency distribution in N-ENS — 2012
Size frequency distribution in N-ENS — 2013
Size frequency distribution in N-ENS — 2014
Size frequency distribution in N-ENS — 2015

Figure 12. Size frequency distribution of N-ENS at-sea-observer monitored Snow Crab broken down by carapace condition. Vertical lines indicate 95 mm CW.

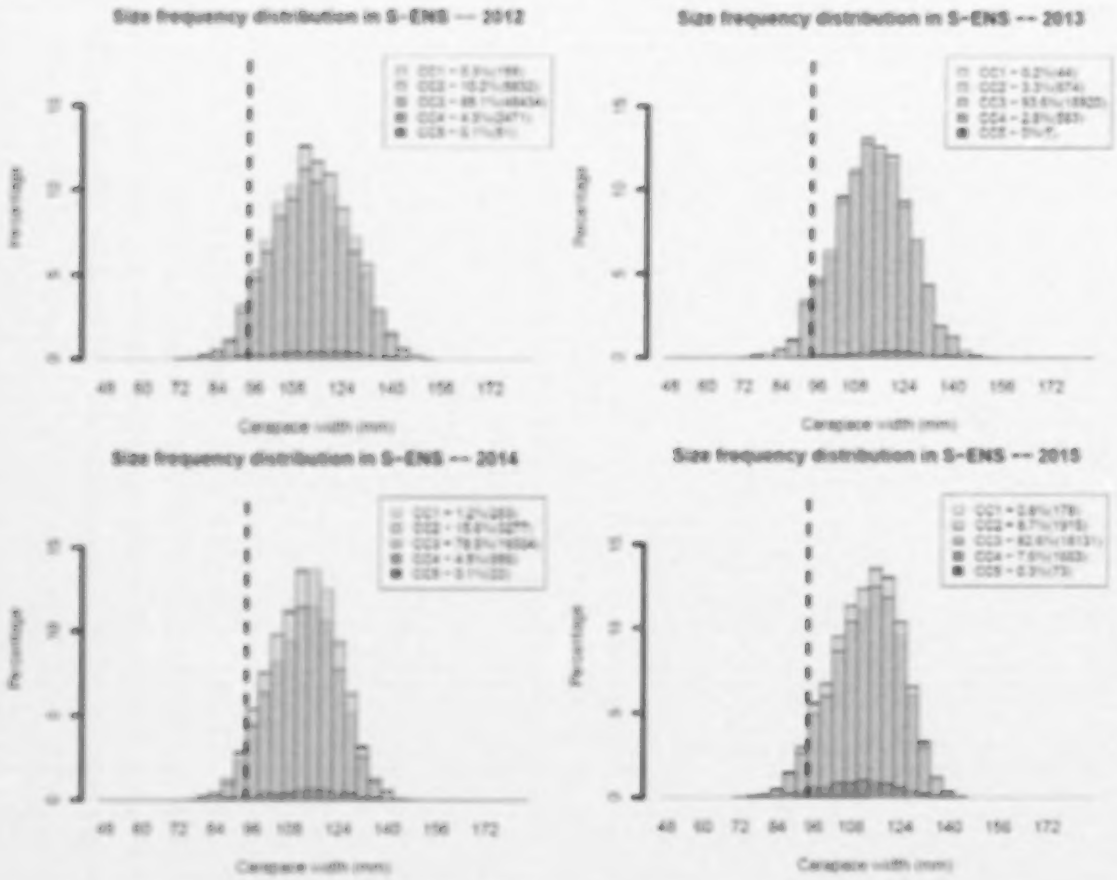

Size frequency distribution in S-ENS -- 2012
Size frequency distribution in S-ENS -- 2013
Size frequency distribution in S-ENS -- 2014
Size frequency distribution in S-ENS -- 2015
Percentage
Carapace width (mm)
48 60 72 84 96 108 124 140 156 172

Figure 13. Size frequency distribution of S-ENS at-sea-observer monitored Snow Crab broken down by carapace condition. Vertical lines indicate 95 mm CW.

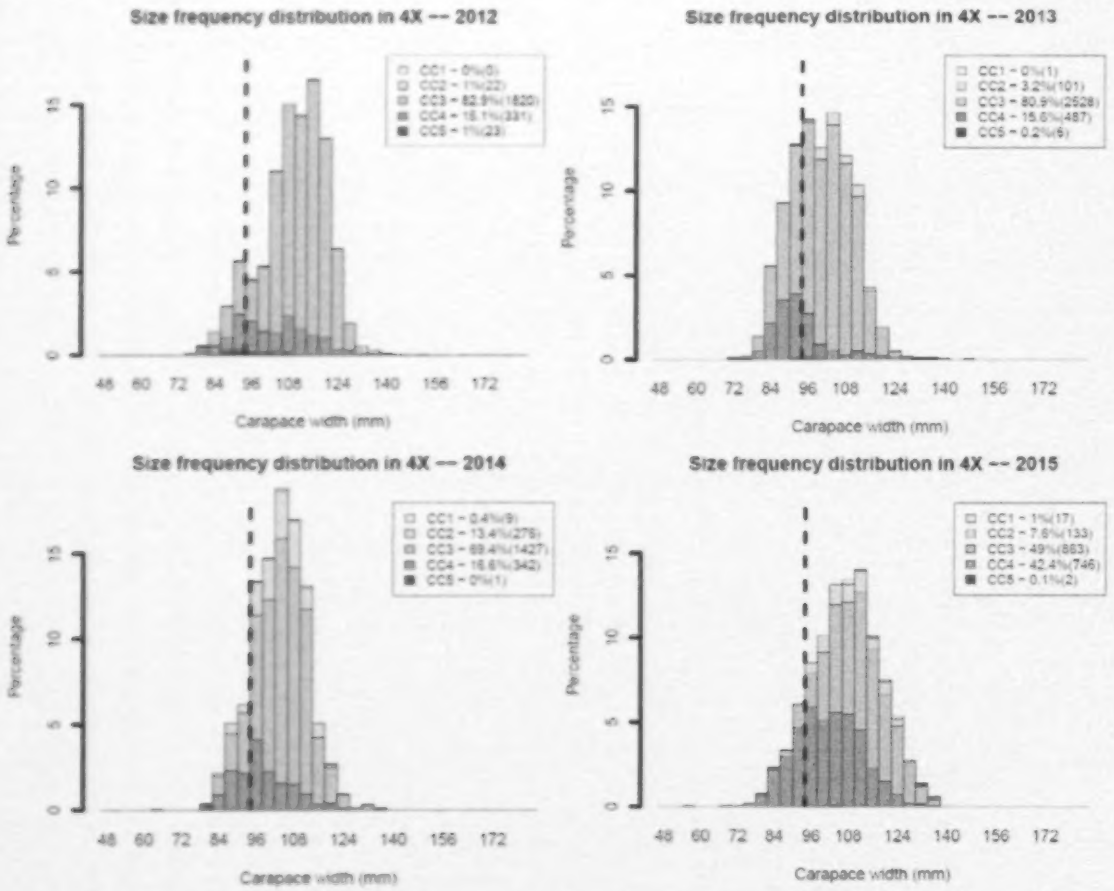

Size frequency distribution in 4X -- 2012
Size frequency distribution in 4X -- 2013
Size frequency distribution in 4X -- 2014
Size frequency distribution in 4X -- 2015
Percentage
Carapace width (mm)
48 60 72 84 96 108 124 140 156 172
0 5 10 15

Figure 14. Size frequency distribution of 4X at-sea-observer monitored Snow Crab broken down by carapace condition. Year refers to the starting year of the season. Vertical lines indicate 95 mm CW.

Recruitment

Based on size-frequency histograms of the male Snow Crab population, very limited internal recruitment to the fishery is expected (similar to 2014) in N-ENS and 4X (Figure 15). In N-ENS, a gap persists between 75 and 95 mm carapace width. This gap is expected to maintain depressed recruitment levels for the next 2-7 years, without immigration of crab from adjacent crab fishing areas. However, a pulse of immature crab, first observed at the smallest size classes in 2010, continues to propagate through the system in N-ENS. Each year the gap between this pulse and commercial size decreases, increasing the likelihood of these animals recruiting to the fishery. Area 4X also shows minimal potential for internal recruitment to the fishery. Within 4X, movement of crab from CFA 24 is potentially an important source of crab entering the fishery and a lack of any commercial fishing effort on the western portion of CFA 24 potentially benefits 4X. Immigration of crab from outside a given area can represent recruitment to the fishery but can be unreliable and difficult to estimate, based on its episodic nature. Information obtained through movement studies may help define immigration / emigration patterns.

In S-ENS, internal recruitment is expected to remain at moderate/ consistent levels. The presence of small immature male Snow Crab spanning most size ranges in S-ENS (20-95 mm CW) observed by the survey suggests that recruitment to the fishery is likely for the next 4-5 years.

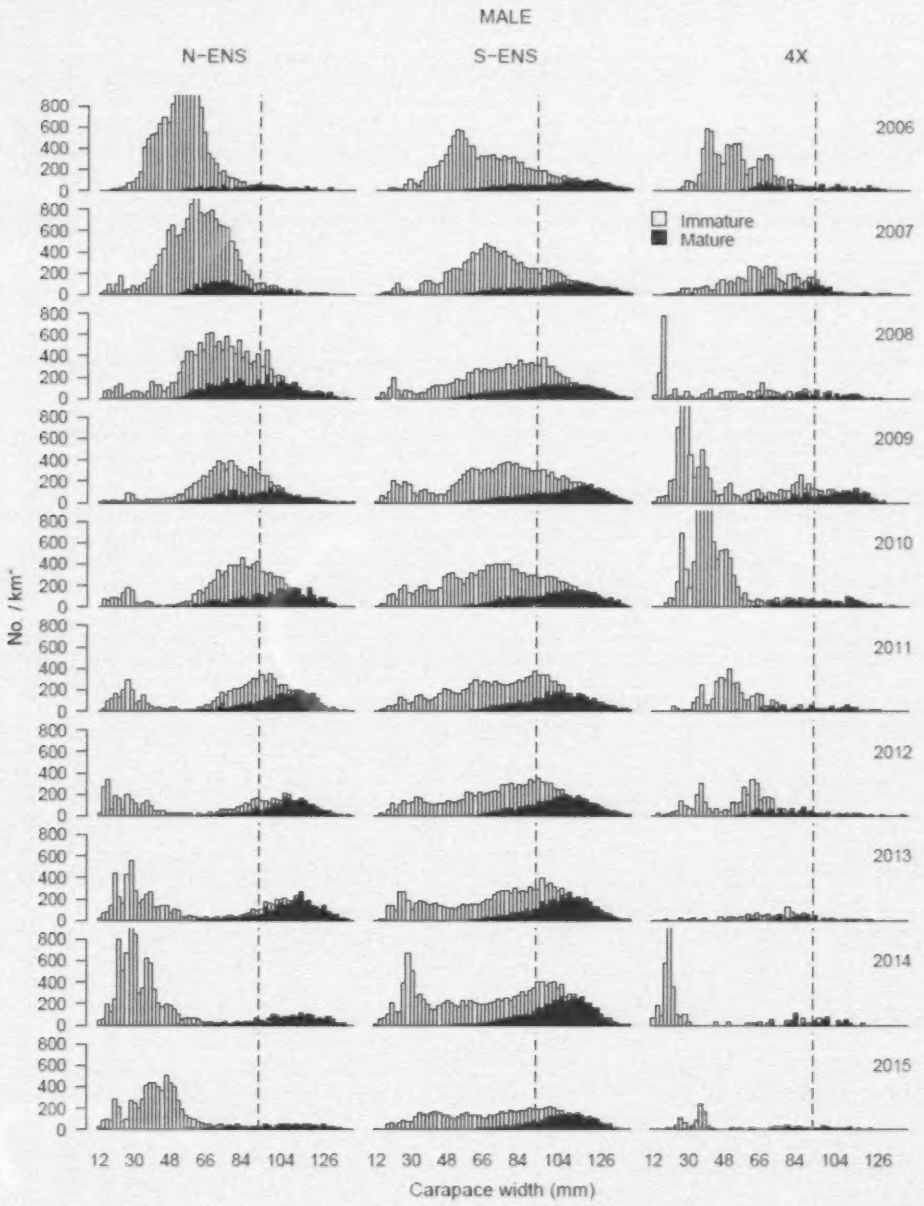


Figure 15. Size-frequency histograms of carapace width of male snow crab. Note the relatively uniform distribution of adolescent crab across all size classes in S-ENS as compared to other areas. For S-ENS and 4X (but not in N-ENS) the spatial extent of the survey has changed over time, making a direct comparison of numerical density inappropriate. This figure provides information about the relative numbers within a given year. The vertical line represents the legal size (95 mm).

Reproduction

Sex ratios (proportion female) continued to be male dominated in N-ENS and S-ENS. When the relative number of mature females is high, the possibility of reproductive limitation is present, as there is an absence of large mature males able to mate and protect more rapidly maturing and smaller females. Mature female abundance has increased slightly in N-ENS, likely caused by the earliest maturing animals of a recruitment pulse propagating through the system in all areas since first being observed in 2010. Sex ratios are low, but stable in S-ENS (Figure 16) with geographic pockets of mature females and mature males. In 4X, mature female abundance continues to be at moderate levels, increasing from 2014.

Based on size frequency histograms (Figure 17), newly matured female crab are expected in N-ENS and S-ENS areas for the next 3-4 years. In 4X, newly matured female crab are expected within 2-3 years. Female Snow Crab of a given year-class will mature 2-4 years earlier than a male from the same year-class. As such, male crab from the same cohort are expected to begin maturing in 2-4 years. Each newly matured female should support egg production for 3-5 years.

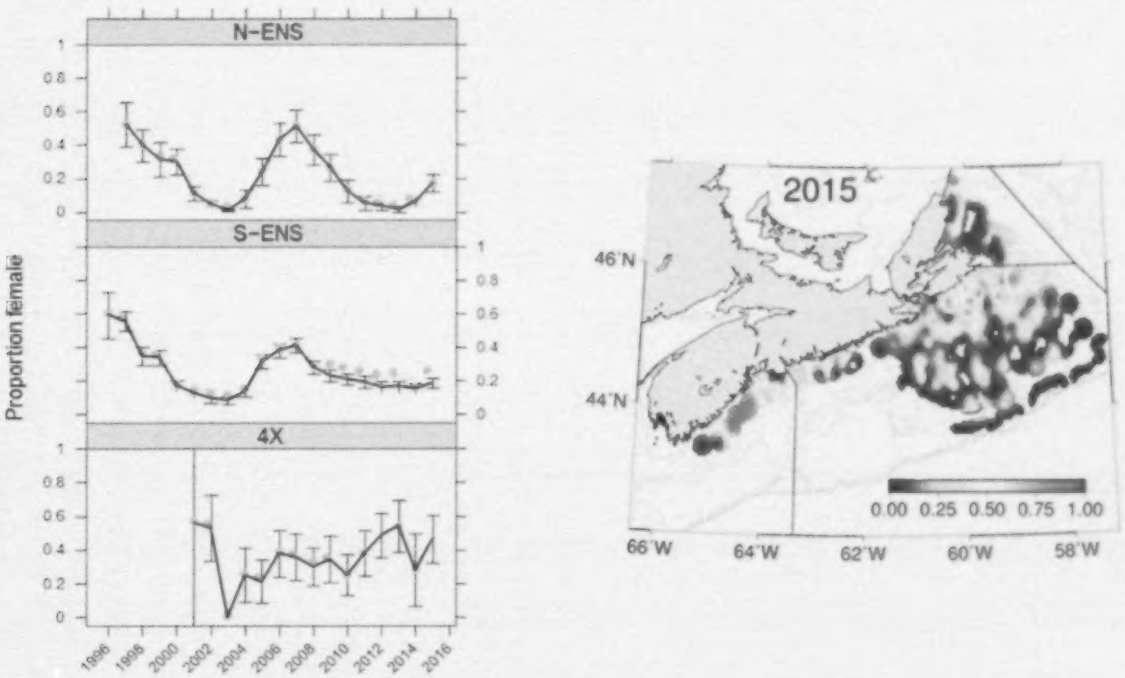


Figure 16. The temporal and spatial of the proportion of mature females to males in the Snow Crab survey data. Note the heterogeneous distribution of sexes in all areas.

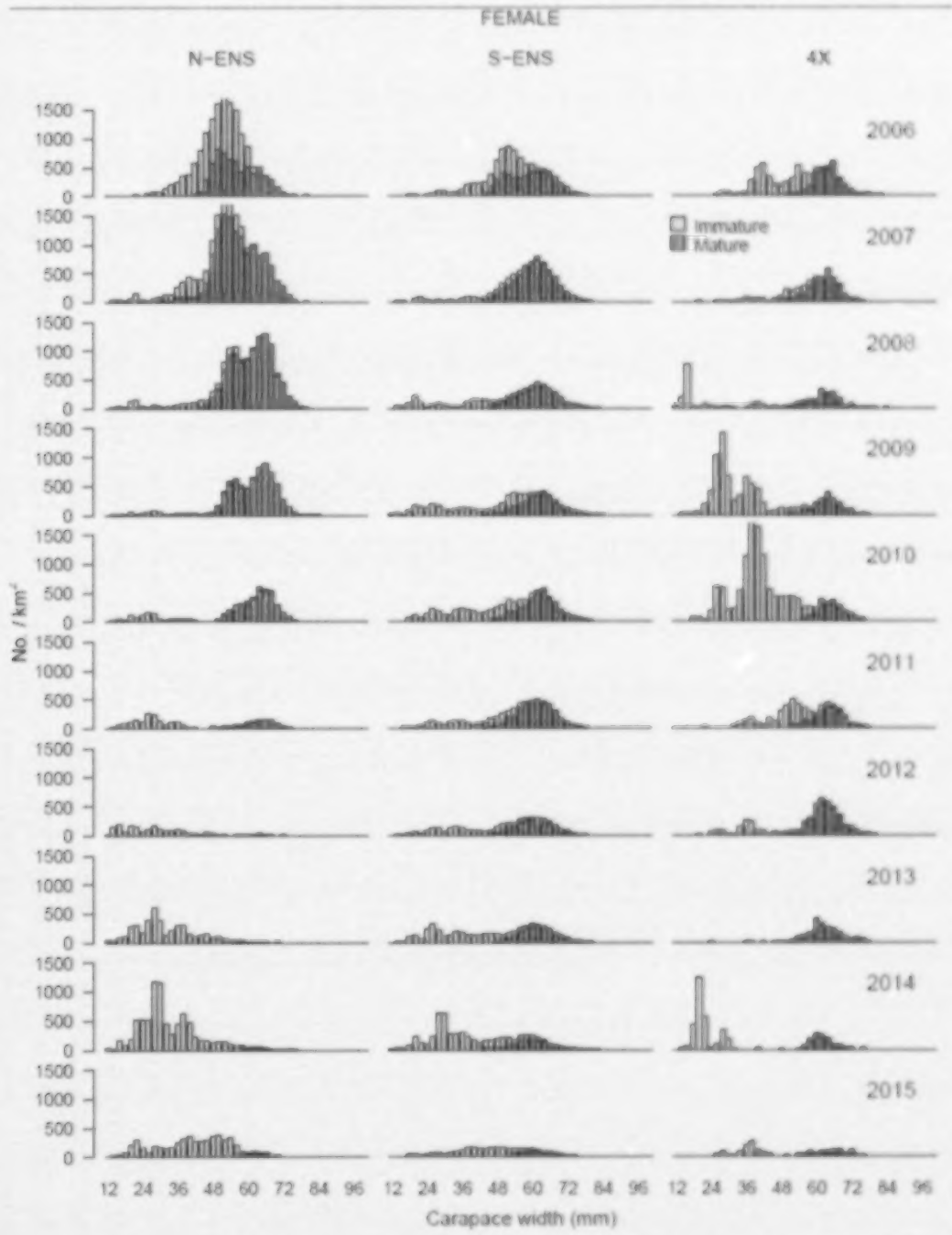


Figure 17. Size-frequency histograms of carapace width of female Snow Crab. Note that for S-ENS and 4X (but not N-ENS) the spatial extent of the survey has changed over time, making a direct comparison of numerical density inappropriate. This figure provides information about the relative numbers within a given year.

Fishable Biomass Index

The spatial and temporal distribution of fishable biomass densities are shown in Figures 18-21. Habitat-adjusted fishable biomass estimates[3] were not available at the time of writing of this summary. As such, the fishable biomass index was estimated as the geometric mean abundance scaled by the catchability estimated by the surplus production model. It is anticipated that these estimates will be conservative compared to the habitat-adjusted fishable biomass estimates.

In N-ENS, the post-fishery geometric mean fishable biomass[4] index of Snow Crab in 2015 was 1,429 t, relative to 2,707 t in 2014, representing a 47% decrease (Figure 21). This decreasing trend has been observed for the past four years. The geometric mean fishable biomass is below the long-term average (Figure 19). In N-ENS declines in fishable biomass were evenly spatial distributed (Figure 18). An increased fishable biomass was found in three tows in west of the Glace Bay Hole area (Figures 18 and 20).

In S-ENS, the post-fishery geometric mean fishable biomass index of Snow Crab in 2015 was 40,541 t, relative to 62,162 t in 2014, representing a 35% decrease (Figure 21). The Scotian Slope, and upstream areas of the Gully experienced the largest changes in fishable biomass from 2014 (Figures 18 and 20).

In 4X, the pre-fishery geometric mean fishable biomass index was 651 t, relative to 1,563 t in 2014, representing a 58% decrease (Figure 21). The 2014 biomass estimate in 4X was, however, highly uncertain as only a subset of survey stations in the areas of highest densities were completed in 2014 (Figure 18). A comparison to the 2013 fishable biomass index is more relevant, which was 260 t, representing a 150% increase from 2013. The spatial distribution of fishable biomass in 4X was patchy, with little or no change in fishable biomass in the majority of tows that surveyed in both 2014 and 2015 (Figure 18).

[3] The fishable biomass, expanded to the area where the probability of occurrence of fishable crab is greater than 0.05.
[4] The geometric mean biomass, per area, based on tows conducted during the annual Snow Crab survey

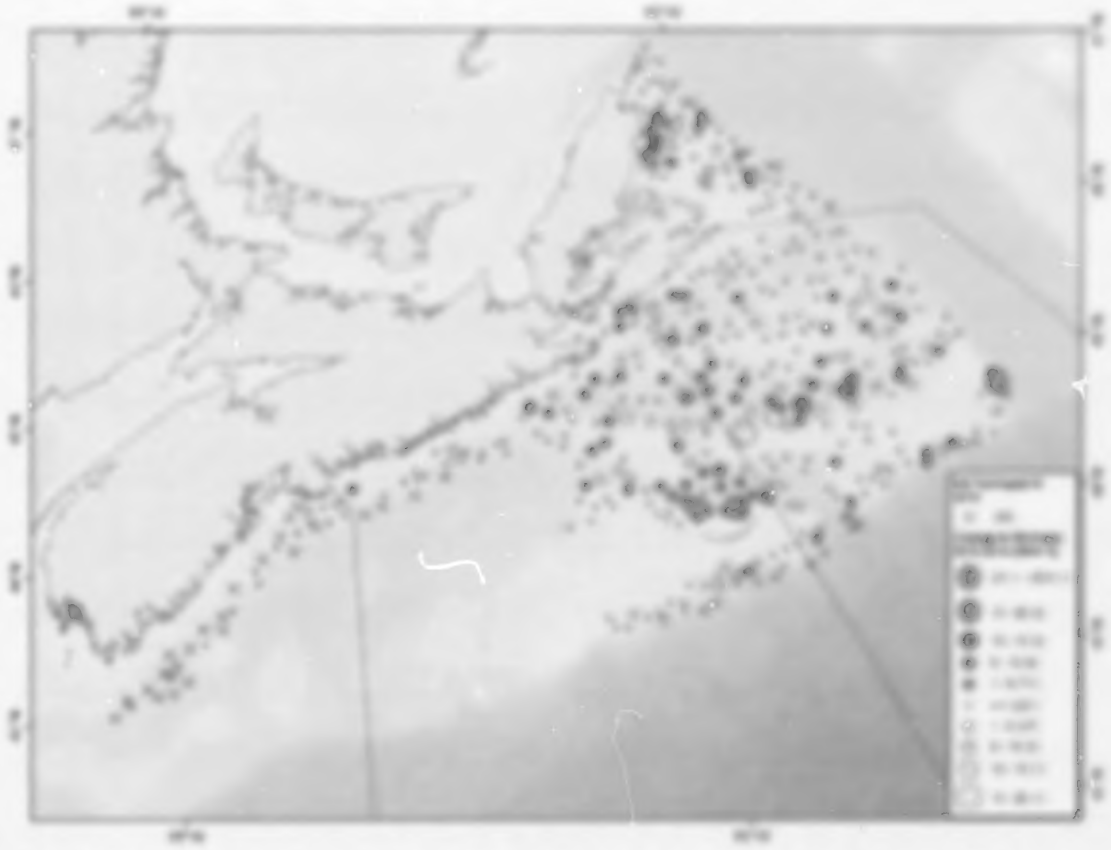


Figure 18. Change in fishable biomass (t/km^2) from 2014 to 2015 (2015-2014) in the Snow Crab survey. Red dots indicate a decrease in biomass found at that location in 2015, while green dots indicate an increase. An X on the map indicates a station that was not surveyed in 2014, but surveyed in 2015. Only a subset of survey stations were completed in 2014

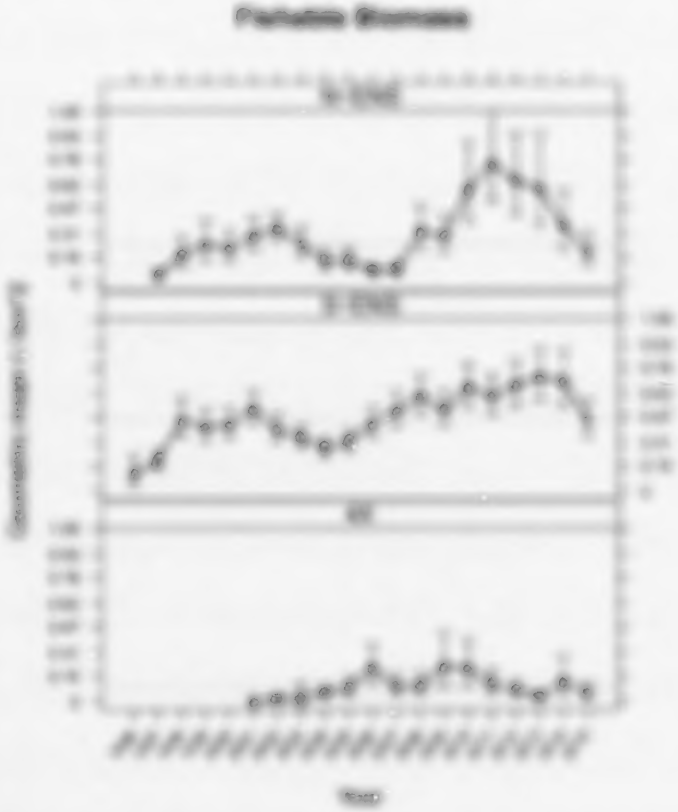
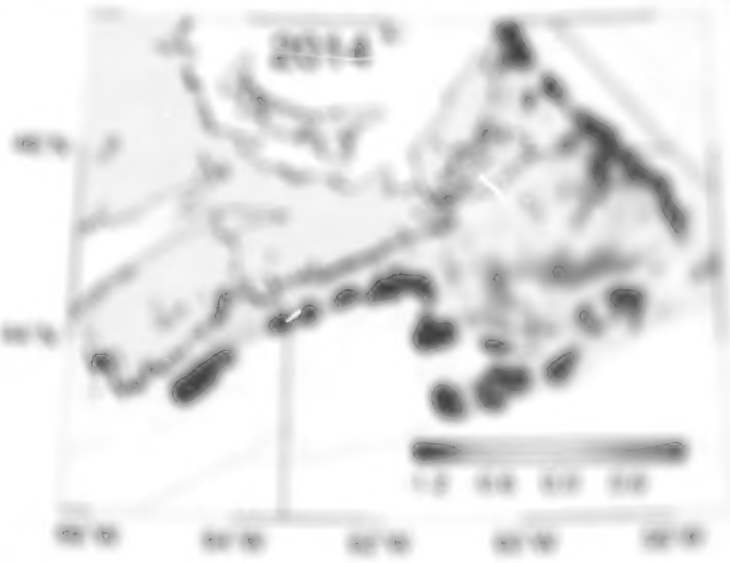


Figure 16. Temporal trends in the geometric mean Panulirus biomass (tows^{-1}) found in the Snow Crab survey.



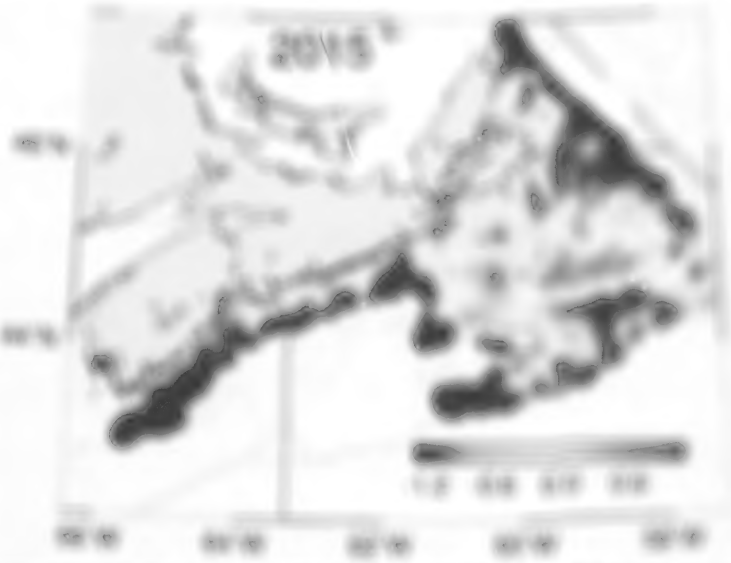


Figure 10. Interpolated fishable biomass from the 2014 and 2015 Snow Crab survey. Light=lighter

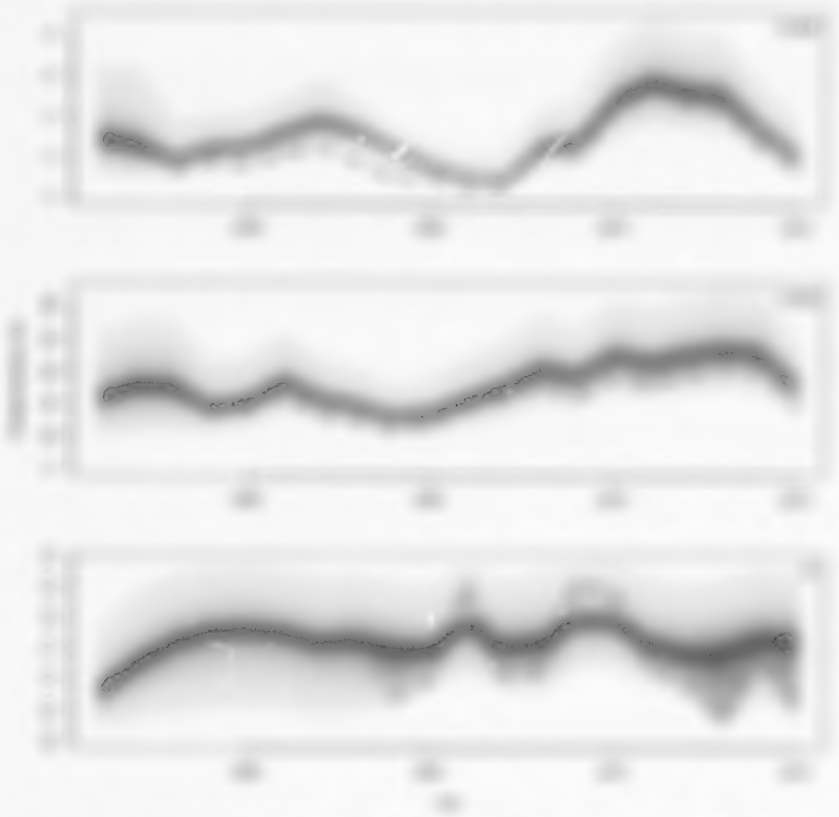


Figure 3 – Time series of fishable biomass from the logistic population models. The shaded (grey/pink) area indicates biomass index in tonnes on a given day. The (yellow) area indicates biomass, estimated from the logistic population model, in tonnes for a long standard trip. The density distributions (in purple) indicate biomass estimates per productivity group with the darkest (and most) being fishable (middle) biomass (B).

Precautionary Approach

a) A 2015 the modelled fishable biomass[1] has decreased over the past four years, and placed the stock into the "cautious" zone (<BF – <TR – <LIM - Figure 3c).

b) A 2015 the population is considered to be in the "healthy" zone (TR – <BF - Figure 3c).

c) By despite a large modelled fishable biomass decrease this year, the population is still considered to be in the "healthy" zone (TR – <BF - Figure 3c). However, since comparison of 2014 and 2015 results is difficult due to inaccurate survey coverage in 2014 (– 3), There was little or no change in fishable biomass in the majority of stock that were surveyed in both 2014 and 2015).

[1] The fishable biomass estimated by the surplus production (logistic) model.

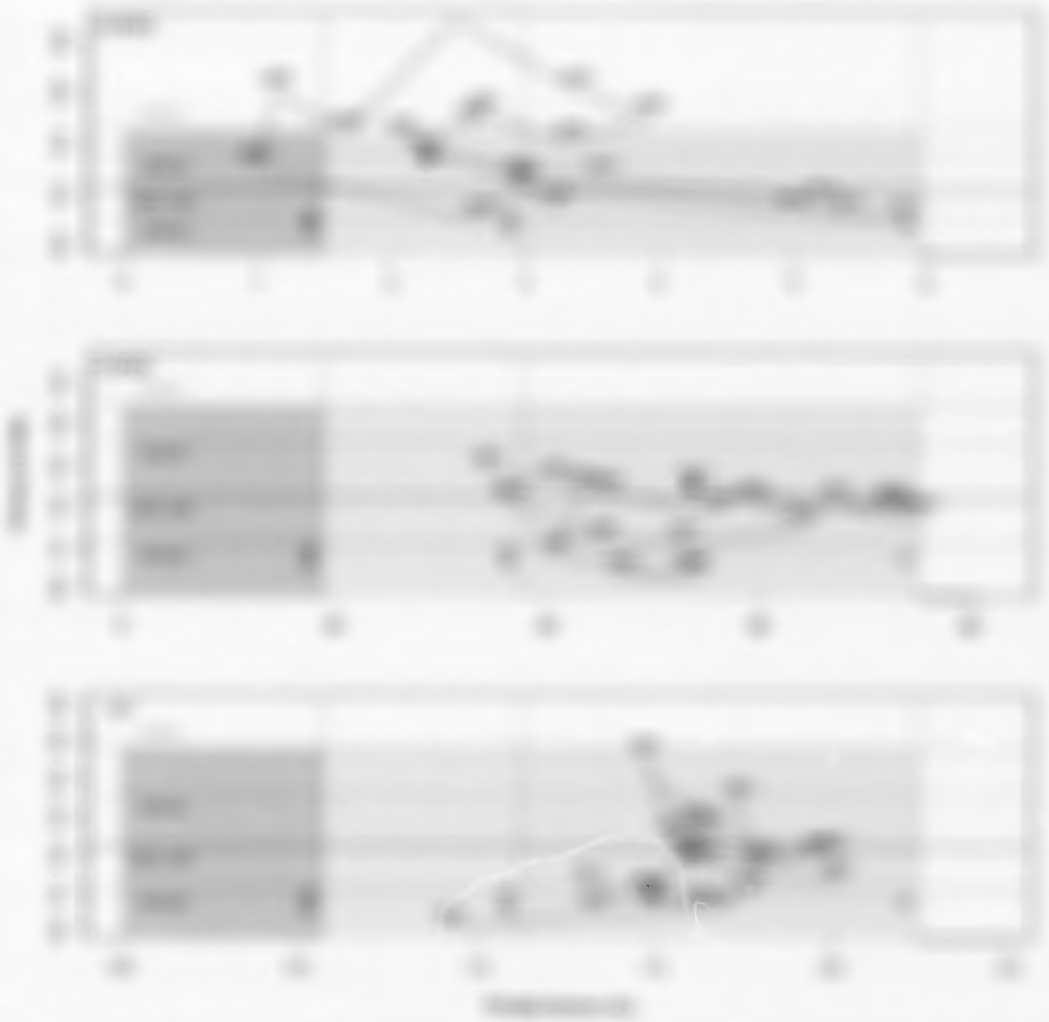


Figure 1.4 - Time series of fishing mortality and fecundity estimates for Atlantic cod (*Gadus morhua*) off Newfoundland, Canada. Estimates from the Canadian assessment model, updated with data from 2010 to 2015. Data from Brattey et al. (2016).

Fishing Mortality

In the 1960s, average fishing mortality (*F*) was lower, estimated to have been in the range of 0.1 to 0.2, peaking in 1969 (Figure 1.4). *F* then increased, reaching a peak of 1.8 in 1978. Fishing mortality was reduced to less than 1.0 over the next 3 years, but then increased to 1.8 in 1984. *F* was then reduced to 0.2 in 1994 and remained at this level for 10 years. *F* subsequently increased to 0.6 in 2006 and has remained at a relatively low level since.

Spawning stock biomass (SSB) was relatively stable, ranging from 1.0 to 1.5 million tonnes, peaking at 1.5 million tonnes in 1962 (Figure 1.4). SSB then declined to less than 0.5 million tonnes in 1978. SSB remained at this level for the next 15 years. In 1993, a moratorium was declared on cod fishing in Canada. As a result of the moratorium, spawning stock biomass was reduced to less than 0.1 million tonnes. SSB remained at this level for the next 10 years. Subsequently, SSB increased to 0.3 million tonnes in 2015.

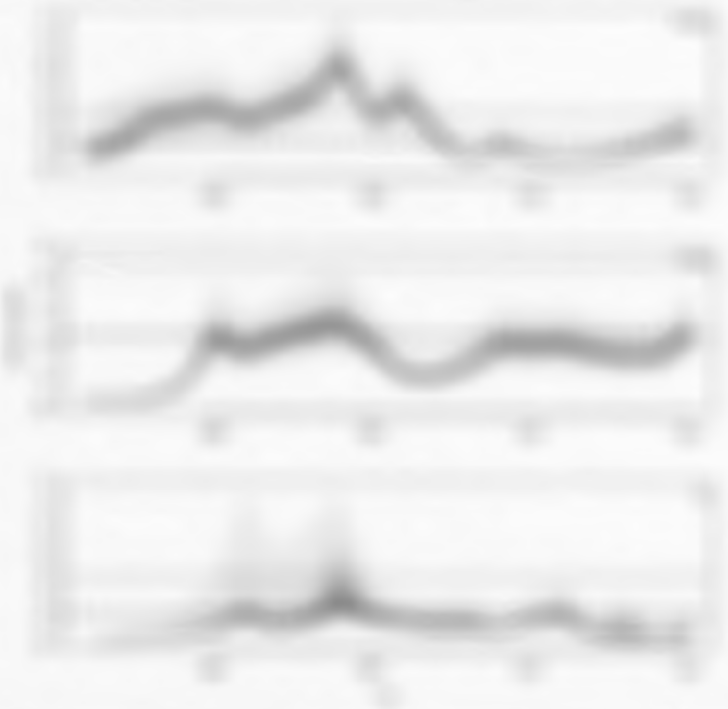


Figure 1.1 – Three-panel line chart showing monthly values for a single quantitative variable over a multi-year period, with the vertical axis labeled in arbitrary units and the horizontal axis labeled with abbreviated month names. Each panel corresponds to one year, and the panels are stacked vertically with shared axis scales.

Answering Questions

Each item is worth 1 point unless otherwise noted. Mark your answer by filling in the corresponding circle. Only one response per item is accepted.

1. Which of the following statements is supported by the figure?
   - A. Values in the second year were consistently higher than values in the first year.
   - B. Values in the third year showed the largest month-to-month increase.
   - C. The figure provides no information about year-to-year comparisons.
   - D. Values in the first year were consistently higher than values in the second year.

2. Based on the figure, which month had the lowest value in the first year?
   - A. January
   - B. February
   - C. March
   - D. April

Estimates for 6X should be considered highly uncertain, due to the brevity of their data series and uncertain nature of their distributions.

Conclusions

Habitat-adjusted fishable biomass estimates were not available for this assessment. As such, the fishable biomass index was estimated as the geometric mean abundance scaled by the catchability estimated by the surplus production model. It is expected that these estimates will be conservative compared to the habitat-adjusted fishable biomass estimates.

N-ENS

In N-ENS the geometric mean fishable biomass has decreased over the past four years, and placed the stock into the "cautious" zone. In 2018, geometric mean fishable biomass decreased by 47%. Fishing mortality in 2018 was estimated at 35%, and has also been increasing over the past few years, due to lack of recruitment into the fishery. Depressed recruitment into the fishery is expected for the next 5-7 years, without immigration of crab from adjacent fishing areas. Recruitment is expected to recover in the long-term; newly mature female Snow Crab are expected in N-ENS for the next 3-4 years, and sex ratios are recovering from near zero. Movement is potentially an important source of crab in this area, but is unreliable and difficult to estimate, based on its episodic nature. Based on the biomass trends obtained during the survey and recruitment patterns, until a strong and persistent increase in fishable biomass is observed, the harvest control rules for the "cautious" zone are to maintain harvest rates between 3% and 20%. A decreased TAC is recommended.

S-ENS

In S-ENS the population is considered to be in the "healthy" zone. There was, however, a large decrease in geometric mean fishable biomass (35%). This decrease was likely over two years, due to a slightly inflated geometric mean biomass estimate in 2016. Fishable biomass appeared to be retracted to primary habitat due to warmer temperatures surrounding primary Snow Crab habitat. Similarly, the spatial distribution of higher landings and catch rates decreased. Increasing temperatures are expected to have long-term effects decreasing the available Snow Crab habitat.

Despite long-term habitat concerns, the population is still high compared to historic levels and recruitment into the fishery is stable. Fishing mortality is currently slightly above the 20% exploitation rate (23%) and at the highest level since the early 2000's. Biomass of predators has been increasing over time, and potentially has long-term effects on biomass. Harvest control rules for the cautious zone are to maintain harvest rates between 10% and 30%. A decrease in TAC is recommended to maintain the 20% exploitation rate.

4X

Area 4X is the southern-most area of Snow Crab distribution, existing in more "marginal" environments relative to the "prime" areas of S- and N-ENS. An explicitly FA towards the fishery is essential in this area. Further, the lower recruitment into the fishable biomass and the large inter-annual temperature variations (especially in 2012) increases the uncertainty associated with this area. In the past, S-ENS has been assumed to provide a buffer for 4X via immigration as evidenced by a large portion of 4X's commercial biomass being proximal to the S-ENS line. Direct comparison of 2018 and 2016 results are difficult due to a much reduced survey in 2018 in 4X. However, there was little or no change in fishable biomass in the majority of tows that

were surveyed in both 2014 and 2015. Recruitment patterns show minimal recruitment is expected into the fishery over the next 2-3 years. Based on the fishable biomass of survey stations surveyed in both 2014 and 2015, and expected recruitment, a decrease in TAC is recommended pending further analysis prior to the 2015/2016 season.

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Sources of Information

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